Original Article

Can Previously Bleached Teeth Be Bonded Safely Using Self-etching Primer Systems?

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ABSTRACT

Objective: To test the null hypothesis that there is no statistical significance in (1) bond strength and (2) failure site location with bleached and unbleached enamel prepared with Transbond Plus Self-etching Primer between different time intervals.

Materials and Methods: Sixty freshly extracted human premolar teeth were randomly divided into three groups of 20 teeth each. Bleaching treatment was performed at two different time intervals (bleaching immediately before bonding and bleaching 30 days before bonding). All brackets were bonded with a self-etching primer system. The shear bond strength of these brackets was measured and recorded in MPa. Adhesive remnant index (ARI) scores were determined after the brackets failed. Data were analyzed with analysis of variance, Tukey, and χ^2 tests.

Results: The bond strengths of group 1 (no bleaching, mean: 17.60 $\pm$ 7.93 MPa) and group 3 (bleaching 30 days before bonding, mean: 13.95 $\pm$ 5.23 MPa) were significantly higher ($P < .05$) than that of group 2 (bleaching immediately before bonding, mean: 11.45 $\pm$ 5.25 MPa). No statistically significant differences were found between groups 1 and 3 ($P > .05$). ARI scores were significantly different among the three groups. In groups 1 and 2, there was a higher frequency of ARI scores of 2 to 4, indicating cohesive failures within the resin. In group 3, the failures were shown to be adhesive (resin/enamel interface) and cohesive characteristics.

Conclusion: The use of a carbamide peroxide bleaching agent immediately before bonding significantly reduces the shear bond strength values of self-etching primer systems.

KEY WORDS: Bleaching; SEP

INTRODUCTION

Many of the bleaching systems available today use different concentrations and various application forms as the active bleaching agents.[1–11] Vital tooth bleaching with carbamide and/or hydrogen peroxide has been recognized as a conservative and safe procedure for treating tooth discoloration.[12,13] Some adults who are interested in orthodontic treatment might have also had their teeth bleached or might be interested in bleaching. Since concerns have been raised regarding changes in enamel surface morphology because of the oxidative process produced by the bleaching gel, it seems important to determine whether bleaching would significantly influence the bonding strength of orthodontic bracket adhesives to the enamel surface.

In routine orthodontic practice, it is essential to obtain a reliable adhesive bond between an orthodontic attachment and tooth enamel. To simplify orthodontic bonding and to save chair time, materials that combine two or more steps have been manufactured. To simplify the procedure and to reduce the time spent for orthodontic bonding, self-etching primer (SEP) systems are available in the dental market that use a mixture combining acid and primer into one solution.[14]

Since the introduction of SEP as an alternative to the traditional acid-etch method, many investigations in operative dentistry have been carried out to evaluate their efficacy. According to White,[15] SEPs are easily manipulated and used, resulting in comfort for the patient and decreasing the chair time by 65%.

In late 2000, a new SEP, Transbond Plus Self-etching Primer (3M Unitek, Monrovia, Calif; TSEP) was de-

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veloped especially for orthodontic bonding. It includes methacrylated phosphoric acid esters, which will both etch and prime the enamel surface before bonding. TSEP has been studied,[14–19] and according to several laboratory tests, using the agent before the bonding of brackets showed promising adhesive results.[16,17]

There have been controversial reports regarding the interaction between bleaching agents and bonding materials to enamel. Some authors have reported significant decreases in the mean shear bond strength of orthodontic brackets to bleached enamel compared with unbleached enamel.[1,7–9,11] However, others found no significant differences in composite bond strengths between bleached and unbleached teeth.[2–4]

So far, to our knowledge, no studies have investigated the effect of bleaching treatment on the bond strength values of metallic brackets bonded with SEP. The purpose of this in vitro study was to determine the effect of bleaching on the shear bond strength and the adhesive remnant index of metallic brackets bonded with TSEP and orthodontic composite at two time intervals (bleaching immediately before bonding and bleaching 30 days before bonding). The null hypothesis to be tested was that there is no statistical significance in (1) bond strength and (2) failure site location to bleached and unbleached enamel prepared with TSEP between the different time intervals.

MATERIALS AND METHODS

Sixty noncarious mandibular premolars extracted with orthodontic indication were used in this study. Teeth with hypoplastic areas, cracks, or gross irregularities of the enamel structure were excluded. The criteria for tooth selection dictated no pretreatment with a chemical agent such as alcohol, formalin, or hydrogen peroxide or any other form of bleaching. Immediately after extraction, the teeth were scraped of any residual tissue tags and washed under running tap water. The teeth were stored in distilled water, and the water was changed weekly to avoid bacterial growth. The sample was randomly divided into three groups of 20 teeth each. All teeth were mounted vertically in a self-cure acrylic so that the crowns were exposed. The buccal surfaces were cleaned and polished with a rubber cup and slurry with pumice and water, followed by rinsing with a water spray and drying with compressed air.

Specimens were prepared for bracket bonding according to one of the following procedures:

Group 1. Twenty premolars were separated as the control group; TSEP was gently rubbed onto the surface for approximately 3 seconds with the disposable applicator supplied with the system. Then, a moisture-free air source was used to deliver a gentle burst of air to the enamel.

Group 2. A commercially available 16% carbamide peroxide bleaching gel (Whiteness Perfect, FGM Dental Products, Joinville, Brazil) was applied with a brush to the enamel surfaces of the embedded teeth in a layer approximately 1-mm thick for 4 hours in 1 day according to the manufacturer's instructions. After completion of the 10 consecutive daily bleaching procedures, the specimens were thoroughly rinsed with a compressed air/water syringe for 30 seconds, air dried, and stored in 250 mL of artificial saliva solution at 37°C. The bonding area was prepared with TSEP as in group 1, before bonding.

Group 3. This group was treated the same as group 2, except that after bleaching and before bonding, the teeth were stored in artificial saliva for 30 days at room temperature. The artificial saliva was changed every day after the bleaching cycle was completed.

Standard edgewise premolar stainless steel brackets (G&H Wire Company, Greenwood, Ind), with a base surface area of 10 mm^2, were bonded to the teeth using the standard protocols according to the manufacturer's instructions. After surface preparation with the TSEP, the brackets were bonded with Transbond XT light-cure adhesive paste. Excess resin was removed with an explorer before it was polymerized. Then, a light-emitting diode (Blue Swan Digital, Dentanet, Istanbul, Turkiye) was used for curing the specimens for 20 seconds.

Debonding Procedure

After completion of the procedures, the embedded specimens were secured in a jig attached to the base plate of a universal testing machine (Hounsfield Test Equipment, Salfords, UK). A chisel-edge plunger was mounted in the movable crosshead of the testing machine and positioned so that the leading edge was aimed at the enamel-adhesive interface. A crosshead speed of 0.5 mm/min was used, and the maximum load necessary to debond the bracket was recorded. The force required to remove the brackets was measured in Newtons (N), and the shear bond strength (1 MPa = 1 N/mm^2) was then calculated by dividing the force values by the bracket base area (10 mm^2).

Residual Adhesive

After debonding, all teeth and brackets were examined under 10× magnification. Any adhesive remaining after bracket removal was assessed with the ARI[20,21] and scored with respect to the amount of resin

Table 1. Descriptive Statistics and Results of the Analysis of Variance Comparing the Shear Bond Strength of the Three Groups Tested

Group Tested[a]	Bond Strength, MPa					
	n	Mean	SD	Minimum	Maximum	Tukey[b]
1	20	17.60	7.93	6.00	39.00	A
2	20	11.45	5.25	6.00	20.00	B
3	20	13.95	5.23	7.00	23.00	A

[a] Group 1, control; group 2, bonded immediately after bleaching; group 3, bonded 30 days after bleaching.

[b] Groups with different letters are significantly different from each other.

adhering to the enamel surface. The ARI scale has a range between 5 and 1, with 5 indicating that no composite remained on the enamel; 4, less than 10% of the composite remained on the tooth; 3, more than 10% but less than 90% remained on the tooth; 2, more than 90% of the composite remained; and 1, all the composite remained on the tooth, along with the impression of the bracket base.

Statistical Methods

All statistical analyses were performed with the Statistical Package for the Social Sciences software package (SPSS for Windows 10.0.1, SPSS, Chicago, Ill). Descriptive statistics, including the mean, standard deviation, and minimum and maximum values were calculated for the three groups of teeth tested. Comparisons of means of shear bond strength values were made with an analysis of variance (ANOVA). Multiple comparisons were done by Tukey tests. The χ^2 test was used to determine significant differences in the ARI scores among the three groups.

RESULTS

The descriptive statistics for the shear bond strengths of the various groups tested are presented in Table 1. The results of the ANOVA indicated statistically significant differences among the three groups ($P = .000$). Thus, the first part of the null hypothesis of this study was rejected. The Tukey test showed that the bond strengths of group 1 (no bleaching, mean: 17.60 $\pm$ 7.93 MPa) and group 3 (bleaching 30 days before bonding, mean: 13.95 $\pm$ 5.23 MPa) were significantly higher ($P > .05$) than that of group 2 (bleaching immediately before bonding, mean: 11.45 $\pm$ 5.25 MPa). We found no statistically significant differences between groups 1 and 3 ($P > .05$).

The ARI scores for the various groups tested are listed in Table 2. The results of the χ^2 comparisons indicated that there were significant differences among the three groups ($\chi^2 = 33.019$, $P = .001$). Therefore, the second part of the null hypothesis of this study was rejected.

DISCUSSION

There is concern that vital bleaching could alter the surface topography of enamel and thus affect the bond strength of adhesives to enamel.[22,23] Alterations in bond strength might be significant with regard to clinical operative procedures that involve composite resin bonding, such as bonding orthodontic brackets, porcelain veneers, composite veneers, or future composite restorations.[3]

It has been proposed that residual oxygen from the bleaching agent inhibits resin polymerization.[1,5,6] Although there are remarkable variations among the recommended postbleaching time periods in different studies (24 hours to 4 weeks), some researchers thought that a delay of at least 2 weeks is needed after bleaching for the tooth structure to regain its prebleaching adhesive properties.[10] Uysal et al[2] stored their samples in artificial saliva for 30 days and suggested that a bonding delay of a minimum 2 to 3 weeks might be beneficial. In the experimental setup of the present study, the bleached teeth in group 3 were stored in artificial saliva for 30 days before bonding to imitate the conditions of the oral cavity.

Compared with phosphoric acid, TSEP produced a uniform and more conservative etch pattern, with regular adhesive penetration and a less aggressive enamel demineralization.[19] It can be inferred from previous laboratory investigations that TSEP can suc-

Table 2. Frequency of Distribution of Adhesive Remnant Index (ARI) Scores (%)

Group Tested[a]	ARI Score[b]						Multiple Comparison	
	1	2	3	4	5	n	Group 2	Group 3
1	2 (10%)	9 (45%)	6 (30%)	2 (10%)	1 (5%)	20	Not significant	***
2	1 (5%)	3 (15%)	6 (30%)	6 (30%)	4 (20%)	20		*
3	0 (0%)	0 (0%)	4 (20%)	9 (45%)	7 (35%)	20		

[a] Group 1, control; group 2, bonded immediately after bleaching; group 3, bonded 30 days after bleaching.

[b] ARI scores: 1, all of composite, with impression of bracket base, remained on tooth; 2, more than 90% of composite remained on bracket base; 3, more than 10% but less than 90% of composite remained on tooth; 4, less than 10% of composite remained on tooth surface; 5, no composite remained on tooth.

* $P < .05$; *** $P < .001$.

cessfully bond orthodontic brackets as well as when phosphoric acid is used with Transbond XT primer.[16,17,24] However, a review of the literature indicated that no researchers have investigated the effect of bleaching treatment on the bond strength of metallic brackets bonded with orthodontic composites to enamel that been prepared with TSEP.

We found no statistically significant differences in bond strength between the control group (group 1) and teeth bonded 30 days after bleaching (group 3). Group 2 (bonded immediately after bleaching) showed significantly lower shear bond strength values than the others.

There is an obvious controversy in the literature related to postponing the bonding procedure after bleaching. Previous investigations have demonstrated that immersion of in vitro specimens in distilled water, artificial saliva, or even saline solution results in a complete reversal of the reduced enamel bonds.[1,3,5,8,9,23] Similar to the present results, some authors have shown a significant increase in bond strength for teeth bonded 1 week/30 days after bleaching.[1,25] However, Cacciafesta et al[7] found that both bleaching groups (bonding immediately or 1 week after bleaching) have significantly lower shear bond strength values than do unbleached controls. Some of the studies in the literature found no significant differences between the groups bleached at two time intervals.[2,7,10] When using TSEP for the enamel surface preparation, the result of the present study is in agreement with those findings assuming that the immersion process is removing the residual oxygen from the bleaching material and that the tooth structure regains its prebleaching adhesive properties.[10]

Reynolds[26] suggested that a minimum bond strength of 6 to 8 MPa is adequate for most clinical orthodontic routine clinical use. All bond strength values of composites used in this study were greater than this minimum requirement and fell within clinically acceptable ranges. However, clinical conditions may significantly differ from an in vitro setting. Moreover, heat and humidity conditions of the oral cavity are highly variable. Because of the probable differences between in vivo and in vitro conditions, a direct comparison cannot be made with the findings of the other studies.

The results of the ARI score comparisons in the current study indicated that there were significant differences among the three groups tested. In groups 1 and 2, there was a higher frequency of ARI scores of 2 to 4, indicating cohesive failures within the resin. In group 3, the failures were shown adhesive (resin/enamel interface) and cohesive characteristics. In the literature, three similar investigations evaluated the ARI scores. Some authors[1,2] have shown a prevalence of cohesive characteristics; however, failures occurred at the enamel-adhesive interface in one study.[7] The differences in the mechanical and physical properties of the materials tested in each study (two-step bonding in the previous studies and TSEP in ours) might explain the variability of the results.[7]

CONCLUSIONS

- The use of a carbamide peroxide bleaching agent immediately before bonding significantly reduces the shear bond strength of teeth bonded with self-etching primer.
- Immersion of bleached teeth in artificial saliva for 30 days before bonding results in a return to control shear bond strength.
- Bleaching and bonding with SEP significantly alters the site of failure during debonding. Especially in group 3 (bleached 30 days before bonding), less residual adhesive remains on the tooth surface.

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